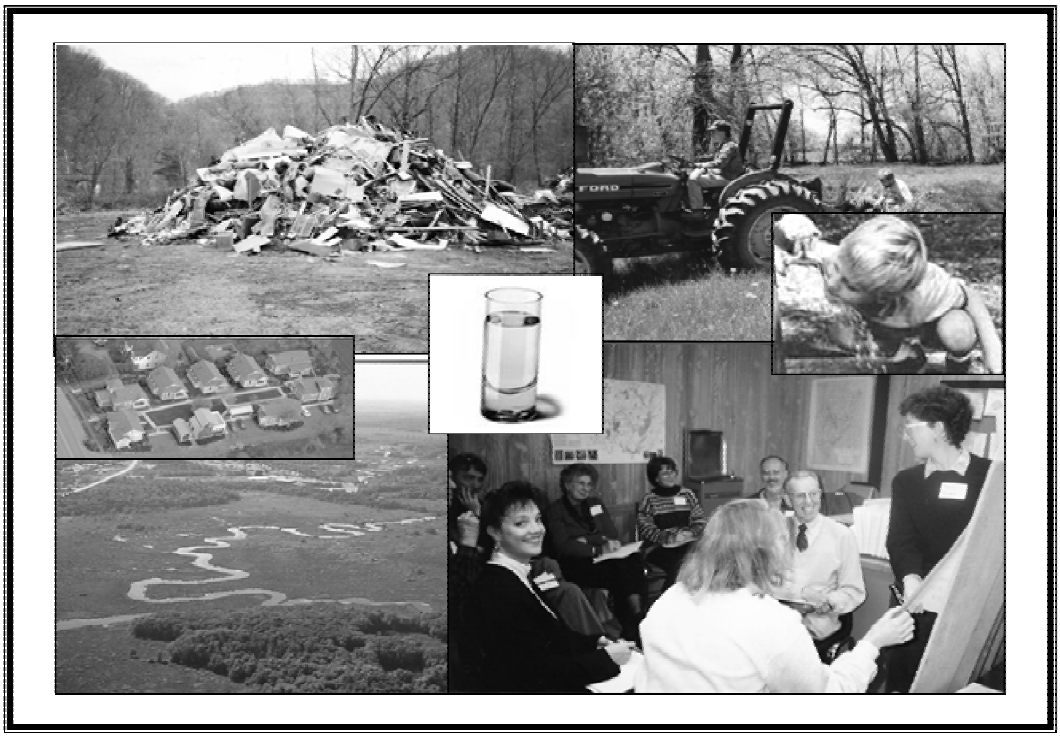
Groundwater Protection
Best Management Practices

A Guide for Local Officials and Public Water Suppliers



Maine Department of Human Services
Drinking Water Program

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I. INTRODUCTION

A. The purpose of this guide

This manual is intended for the use of local officials, public water suppliers and landowners in Maine. It is intended to encourage educated decisions, informed practice, and directed planning in regard to groundwater protection, particularly in the vicinity of public drinking water supply wells.

The purpose of groundwater protection is to avoid contamination from inappropriate land uses located close to public supply wells. The result of sound protection is that water pumped from public supply wells will meet all drinking water standards, now and in the future.

The protection of public and private drinking water supplies involves the following activities:

1. **Delineation** of an area around a well that defines the area from which groundwater flows towards the well. The total area is known as a wellhead protection area (WHPA), and is commonly divided into 2 or 3 zones that provide different levels of protection. Qualified professionals employed by either the Water System or the State Drinking Water Program usually do this work.
2. **Preparing an Inventory** of existing facilities and activities within that area. This work is usually completed by the Water System, and reviewed by the Drinking Water Program.
3. **Management** to avoid threats to groundwater quality by remediating and controlling existing sources of contamination, properly designing new facilities, and limiting certain activities within the WHPA. This work is done by property owners and applicants for new developments, guided by State or local regulations. This last activity is what this manual is intended to support.

B. Threats to groundwater

What is a "Threat to Groundwater"? Consider any land use (industrial, commercial, agricultural or domestic), and ask whether some chemical (liquid, or dissolved from a solid) could find its way down through the soil to the water table below. That is a threat. Once there, the chemical (or bacteria/viruses) will travel with groundwater as it makes its way to a nearby stream or lake. The problem comes when we want to use that groundwater, as pumped from wells or springs, which may be located close to, or in the line of groundwater flow from a threatening land use.

The threat of any suspect land use is site-specific. It will depend on the chemical's solubility and persistence, its toxicity, the volume spilled or leached into the ground, the filtering capability of the local soil, and the proximity of wells.

The only way to deal with groundwater-threatening land uses is to make them less threatening. Preventing spills wherever possible achieves this. One method is to enforce laws and ordinances

intended to engineer the prevention of spills. Foresight, ingenuity and vigilance are required at every stage – in the design and operation of containment facilities, in reductions in the amount of chemicals (such as pesticides and fertilizers) that are spread, and in appropriate siting.

This manual is about siting, and the best management practice for the design of facilities intended to prevent spills such that they pose less of a threat to groundwater around the wellheads of public supply wells. However, much of this best management practice could be taken to apply to land uses in general, such that all groundwater is protected, which is our ultimate goal in Maine.

C. Wellhead protection

Wellhead Protection is a sensible proposal to ensure that the quality and quantity of water pumped from a public supply well is neither degraded nor diminished by unwise land use decisions in the area around the well. Wellhead protection is based upon five basic premises:

- When water is drawn from a well, other water is drawn from the surrounding aquifer toward the well to replace it. The volume of aquifer from which water is drawn will depend upon the geometry and characteristics of the aquifer. Aquifer geometry and characteristics can be determined by hydrogeologic studies. The volume of aquifer involved will also depend upon the pumping rate of the well and amount of recharge to the aquifer. In simple terms, given some geologic information and a few assumptions, one can calculate and draw on a map, a "Zone of Contribution" around the well.
- Some water entering the aquifer is drawn from adjacent surface water bodies such as brooks, rivers and lakes.
- Precipitation falling on land is the ultimate source for all water pumped from wells.
- Rainwater (and snow melt), percolating through soils can wash contaminants into the aquifer (sometimes via adjacent surface water bodies). Such contaminants may pass through the aquifer into the well, and
- It is through the control of land uses in the Zone of Contribution to the well, and in the watershed of contributing surface water bodies, that we can protect the quality of well water and prevent contamination in the future.

D. Wellhead protection in Maine

Currently, the State designates two or three "zones" in the vicinity of the public water supply well. These are sometimes termed "Wellhead Protection Zones", or "Zones of [groundwater] Capture", or "Zones of [groundwater] Contribution". Briefly, they are as follows:

- Zone 1 includes land areas immediately surrounding the well. These areas must receive the greatest levels of protection, namely ownership or control by the public water supplier or community.
- Zone 2 surrounds Zone 1, and should receive some measure of protection by land use controls imposed by local officials working cooperatively with the public water supplier and landowner.

- Zone 3 includes a larger land area that may include the total watershed upgradient of the well. Land use controls are usually no more stringent than current environmental protection regulations, though it is still worthwhile to identify Zone 3 for educational purposes and planning.

The State Drinking Water Program currently has a three-tiered scheme for classifying wellhead protection areas around public supply wells. The three tiers of wellhead protection are as follows:

- Public supply wells in sand and gravel aquifers (gravel-packed wells with screens) must be protected by zones defined by "time of groundwater travel". The process involves computer simulation of groundwater flow towards the well. The boundary of Zone 1 is set at a groundwater travel time of 200 days, which is based upon the expected life of viruses in groundwater. The Zone 2 boundary is set at 2,500 days (7 years), which is the time it might take to identify, study and remediate a chemical spill. Zone 3 may be designated as the contributing watershed to the well in question.
- Public supply wells with higher yields, and obtaining water from bedrock aquifers, are protected by three zones designated by a professional based upon relative confidence that the contributing area is properly identified. Zone 1 is defined with the highest confidence, Zone 2 somewhat less. Zone 3 may be designated as the contributing watershed to the well in question
- Relatively small wells (e.g. those serving schools and restaurants) identify Zone 1 using a calculated fixed radius around the well that is proportionate in area to the number of people the well serves, and thus to the average yield of the well. Zone 2 is designated as a circle with a radius of 2,500 feet. There is no designated Zone 3.

E. Local action in groundwater protection

In Maine, public water supplies, whether they are water districts, water departments, private companies, mobile home parks, schools, or businesses, are responsible for providing safe drinking water. However, unless they own the land around their wells, they have no control over land use.

With the exception of large projects that come under State Department of Environmental Protection review, land use control and regulation in Maine is in the hands of the landowner and the municipality (local Planning Board and Code Enforcement Officer (CEO)). So towns, landowners, and public water suppliers have to work together to ensure protection of drinking water supplies.

One of the most effective ways to accomplish this is to develop and adopt a local wellhead protection or drinking water protection ordinance, or include wellhead/drinking water protection provisions in the local land use ordinance(s). This Guide, the Best Management Practices (BMPs), and the accompanying model ordinance have been developed specifically to help local communities protect their drinking water supplies. Even without a specific ordinance, the BMPs (Section V below) can be used as guidance and education for landowners and developers. They can be used to help in reviewing developments, as conditions of approval, as performance standards, or advice for landowners who may not come under official municipal review.

F. How to use this guide

1. Scan the introductory material to this manual (Sections II and III). Even if you read the headlines, you will find it educational.
2. Become familiar with the Public Water Well that is the subject of your deliberations, including its location and specifics of the delineation of the Wellhead Protection Area around it.
3. Work through the List of Potential Contamination Sources (Section IV, Table 1) until you find the one or ones that most closely fit the facility with which you are concerned.
4. Find the major activities that are associated with that PCS (Table 1, The letter codes in this table refer to the subsections of Section V of this manual).
5. Read subsection Descriptions, and Major Threats.
6. Consider which BMPs should apply.
7. Apply them cautiously. This is your responsibility as a Planning Board. Be aware that facilities change in use over time.

II. PRINCIPLES OF GROUNDWATER CONTAMINATION

The following general principles may help in understanding how groundwater contamination occurs and how it can be avoided.

A. Piling up of materials or waste can be a problem

This applies to all kinds of materials and wastes. For instance, wood wastes, including stumps, when left in the woods, do not adversely affect groundwater quality. However, when such wastes are stored in large quantities, for instance at a lumberyard or in a stump dump, they can cause groundwater beneath and downgradient of the pile to become contaminated. The same can be said of other organic materials, such as stored potato culls.

Unlined landfills are known to produce leachate that can contaminate large volumes of groundwater.

Uncovered sand/salt piles for road maintenance are known to lose up to half of their salt during one season, and to produce leachate that is more concentrated than sea water.

B. Everything is soluble

All chemicals are soluble to some extent, even those that we think of as not mixing with water, like gasoline. The extent to which any particular chemical is likely to be a groundwater contaminant will depend upon several factors, including: the volume used and how it is used, its solubility, and its ability to sorb onto soil materials or to biodegrade.

C. Heavier than water solvents are a witch's brew

Chlorinated solvents, such as perchloroethene (the dry-cleaning solvent), trichloroethene (a common degreasing solvent) and methylene chloride (a common paint remover) are all heavier than water. If spilled on the ground, they tend to sink through soils to the water table. From here, they may sink to any depth within an aquifer. They biodegrade slowly, sometimes producing daughter chemicals that are more toxic than the original compound. Spills are very difficult or near impossible to remediate.

D. Metals are controlled by pH (acidity), and Eh (oxidation/reduction potential)

Concentrations of metals in water are usually far higher in more acid and/or more reduced conditions. Reducing conditions in groundwater are normal beneath a wetland, or in other natural situations. Thus when groundwater receives recharge from wetland areas, concentrations of iron and manganese pumped from wells are usually high. The same kind of situation can arise around plumes of contaminated groundwater, such as that originating from a landfill or a gasoline spill.

E. Pathogens

Pathogens such as bacteria and viruses occur in domestic and municipal wastewater (in septic systems and sewers), manure, and even runoff from lawns. Pathogens are rare as groundwater contaminants except when leachfields are too close to a well, and/or the well is not properly constructed. Bacteria have a tendency to attach onto soil particles, and are not common groundwater contaminants. However, they can migrate rapidly to groundwater through shallow bedrock fractures or coarse gravel soils, and can also get into wells through insecure casings. Little is known about viruses as groundwater contaminants, except that they remain viable up to 150 days. There are no routine analyses for viruses in groundwater.

F. Organic chemicals

While many natural organic chemicals degrade rather readily, there are many synthetic organic chemicals that do not. Gasoline additives such as MTBE (methyltertiarybutyl ethanol), ETBE (ethyltertiarybutyl ether) or TBA (tertiarybutyl alcohol) are water soluble and can travel great distances from the site of a spill.

G. Dispersion is negligible

We used to think that groundwater contamination spread fan-like away from a spill site. Recent discoveries show that most "plumes" of groundwater contamination are shaped more like a pencil, and are not wider than the source of the spill.

H. Chemicals in common use are common groundwater contaminants

Some of the most common groundwater contaminants include salt (from deicing of roads in winter, or from sea water intrusion in coastal areas), nitrate (from over-use of fertilizers, or from

septic system leachate), gasoline (from spills), and trihalomethanes (from use of chlorine products and disposal in wastewater in septic systems).

I. Geology is site specific

Every public supply well is located in a unique geologic setting. Gravel packed wells are screened in extensive and thick deposits of sand and gravel. These may or may not be covered by layers of clay that prevent recharge (and contamination) from entering the aquifer in the area around the well. Bedrock wells tap into fractures beneath the surface, which collect large volumes of groundwater both from surrounding fractures and from soils above. All wells pump groundwater that is a renewable resource replenished by rain and snowfall that trickles down through soils. It is the purpose of these BMPs to ensure that this renewable resource is kept as clean as possible.

J. We can make contamination a thing of the past

With education and regulatory/financial incentives we have come a long way to making groundwater contamination a thing of the past. For instance: 1) we have replaced tens of thousands of underground gasoline storage tanks with technology that is designed not to leak; 2) we have replaced the worst degreasing chemicals with citrus-based substitutes; 3) we now line landfills and cover sand/salt piles; and 4) organic farming techniques continue to gain favor.

K. Planning is the key to the future

Planning the location and design of new development with groundwater protection in mind is key. One aspect of planning is the use of BMPs for land uses close to groundwater supplies, such as in Wellhead Protection Areas around public water supply wells. This is an important area of town to protect.

III. PRINCIPLES OF LAND USE REGULATION FOR GROUNDWATER PROTECTION

Because of the differences in town political structure, land use regulation, review and enforcement capacity, it is difficult to make a 'one size fits all' model ordinance and set of BMPs that are appropriate to all situations in all Maine communities. As with other local land use issues, each community will need to determine what will fit and work best in their town. The following are some simple principles that communities can use as guidance when putting together their own set of land use regulations. They can be used with the delineated wellhead protection zones as provided by the drinking water supplier or the State's Source Water Assessment Program.

A. Keep it out

One of the most difficult problems faced by towns is determining how much risk to the water supply they are willing to accept. We can tell you what is absolutely safe (no uses) and what is unsafe (careless location and uses) but the middle ground is less clear.

The simplest way to protect your water supply is to keep potential contamination sources out of the wellhead protection area. Political realities may make this a difficult option to adopt in some towns, but many towns consider the safeguard to the town investment in the water supply and ease of administration and enforcement of 'just saying no' a good trade-off.

B. Keep it from getting larger

If you can't keep a potential contamination source out of the wellhead protection area, you can limit the size or scale. If properly taken care of, a small used car lot may be only a small risk when located in the wellhead protection area. A large truck terminal in the same location may pose greater risks. Someone may need to store fuel for vehicles or equipment, but do they really need three tanks? Try to keep the risks as small as possible.

C. Know what is there

Often the water supplier and the town don't even know when and where a potential contamination source is being used or stored. Make sure that you know what is located in the wellhead protection area, and how to deal with any spills, accidents, and fires. Make sure the land owner/operator knows of his/her potential to affect the water supply.

D. Enforce proper maintenance and proper practice

If a business or landowner is using or storing a potential contamination source, make sure that they are using proper practices to protect the water supply. Use a multi-barrier approach, so that if there is an accident (e.g. a problem with a holding tank or containment structure, or one person fails to do what they are supposed to) there is a back up to protect the water supply.

E. Know when there is a problem

Require those located in the wellhead protection area to promptly notify the town and water supplier when there are spills or accidents involving potential contamination sources.

F. Remember to consider potential future uses

It is tempting to allow structures or uses in the wellhead protection area because they seem innocent enough when they are proposed…or you know the owner and they are very responsible and careful. But remember to consider future changes. What happens when the property changes hands? That 3-bay garage for the hobby woodworker may look like the perfect place for an auto body shop when the property goes on the market! Is this the only place in town it can be located?

G. Summary

These basic principles will help you to set your goals for wellhead protection in your town. How much risk are you willing to live with and for what reasons? Make your goals clear so that they are easily communicated to the public. Then as you review each individual provision you can go back to these goals and check your proposals with what you intend to accomplish.

IV. FACILITIES AND ACTIVITIES THAT REQUIRE ATTENTION

The State Drinking Water Program has a list of Potential Contamination Sources that public water suppliers should consider when developing a wellhead/sourcewater protection plan under the State's Wellhead/Source Water Protection Program. This Guide uses the same list. Because any one *facility* may pose a threat to groundwater in several ways, we have cross-referenced this list to the particular *activities* that pose a threat to groundwater quality.

Table 1 identifies a variety of activities that pose a potential risk of contamination. Major activities are cross-referenced to Section V of this manual. Major threats, relative risks and recommendations for prohibition are listed in the table as well.

V. BEST MANAGEMENT PRACTICES (BMPs) FOR ACTIVITIES THAT POSE A THREAT TO GROUNDWATER

The following BMPs are recommended for the design, construction and operation of activities that may be associated with several of the facilities listed in Table 1.

A. CHEMICAL STORAGE

Definition: Chemical storage includes storage in tanks (above and underground), and in drums of different sizes. It can also include storage of solid chemicals in bags, or in bulk (in piles or silos).

The principal chemicals of concern regarding groundwater contamination include petroleum products, solvents, agricultural chemicals, manure and road salt. Stored waste chemicals are also a concern.

- Petroleum products include gasoline and jet fuels that have low viscosity and soluble components (such as MTBE and benzene), as well as home heating oil. Some petroleum products, like #6 oil, are so viscous that they cannot be considered groundwater contaminants.
- Solvents include a variety of degreasers and cleaners such as trichloroethene, perchloroethene and methylene chloride, all of which are used widely in industrial and commercial facilities.
- Agricultural chemicals include nutrients/fertilizers, and various pesticides (including fungicides, herbicides and insecticides).

- Waste chemicals can include unused paints, paint scrapings, spent solvents, and diluted wash water.

Federal and State regulations make a distinction between Hazardous Materials and Hazardous Wastes. The former can include virgin materials, while the latter results from a process, including spillage. Maine state regulations apply only to hazardous wastes, although for the purposes of this manual, any chemical use can be potentially hazardous. Planning Board decisions should be aimed at preventing spillage in all cases.

State and Federal hazardous waste regulations distinguish small quantity generators (SQG) of waste as those that generate less than about ½ drum (100 kg) of waste per month, and accumulate no more than one drum on site at any one time. For the purposes of this BMP manual, we shall make a size distinction for the storage of hazardous materials also. Large is defined as in excess of 275 lbs solid and 275 gallons liquid. Thus domestic heating oil tanks are all "small" by this definition.

Major potential problems for groundwater:

- Leakage of liquid chemicals from tanks and drums. Note that underground tanks are more liable to produce undetected leaks because they cannot be inspected while in operation.
- Leaching of solid chemicals in bulk, if material is exposed to precipitation.
- Massive leaching with water during fire-fighting emergencies.
- Spills during transport and delivery.

Zoning or land use recommendation:

Zone 1: Prohibit, except for uses of Public Water System
Zone 2: Use BMPs. Limit size as much as possible.

BMPs for chemical storage

Special provisions (*) pertain to large facilities and storage units.

1. Underground storage tanks are prohibited by State law in Wellhead Protection Areas.
2. Store all chemicals under cover, and on impervious working surfaces, without floor drains. Design storage space so that failures, emergencies, extreme storm events or routine site clearing will not cause material or wash water to run on bare ground.
3. * Provide secondary containment to include impervious holding of fluids of at least 20% of the volume of storage of all liquid chemicals, and 110% of the volume of the largest storage container, by permanent dikes or other means.
4. * Tanks for liquid storage shall be equipped with automatic shutoffs and high level alarms. Personnel shall be trained to respond to shutoffs and alarms.
5. All piping shall be designed to prevent line breakage by collision.
6. All containers and piping shall be secure and resistant to corrosion.
7. All containers shall be clearly labeled with name of chemical, and date of purchase (or generation of waste).

8. * Prepare a Spill Prevention, Containment and Countermeasure Plan (SPCC) under DEP guidance (http://www.maine.gov/dep/rwm/spcc/spccissueprofile.pdf), for submittal to the CEO, Fire Department and Water District. This plan shall include provisions to prevent and catch spills during loading and transfer activities. This SPCC plan shall be reviewed and updated annually.
9. *Inspect all storage areas at least weekly, and maintain an inventory and tracking system.
10. Adequate spill clean up materials must be kept on hand at the facility. Spills must be cleaned up promptly, and spilled materials disposed of properly.
11. "Pre-plans" for firefighting must be prepared bearing in mind the possibility that chemicals could cause groundwater contamination if washed out of a burning building by water. Foam materials and spray plans should be included in the plan, appropriate to the materials and quantities stored in the facility.
12. Determine if chemicals being stored are "hazardous" by characteristic (http://www.maine.gov/sos/cec/rcn/apa/06/096/096c800.doc), or are a listed hazardous waste. If materials are either, ensure that DEP's hazardous waste regulations are being followed. In any case follow the BMPs above.
13. Manure, ash, and liming agents used for agricultural purposes must also be stored under cover.

B. CHEMICAL USE

Definition: Chemical use includes but is not limited to: combustion, degreasing and other cleaning, mixing and dilution with other chemicals or water, catalytic reactions, all with or without the production of a waste material. Some waste materials are recycled on a limited scale during the process. Types of chemicals include all those listed above under chemical storage, except for agricultural chemicals, manure and road salt (see section C below).

Major potential problems: Through spillage or disposal, chemical waste materials can reach soils and move through them to groundwater. Spillage or disposal can be intentional or accidental. Many chemicals have been known to contaminate groundwater to above drinking water standards.

Zoning or land use recommendation:

Zone 1: Prohibit, except for uses of Public Water System
Zone 2: Use BMPs. Limit amount of use as much as possible.

BMPs for chemical use:

1. Use non-hazardous chemicals whenever possible. If hazardous chemicals must be used, provide justification for why they cannot be replaced by non-hazardous chemicals.
2. Design chemical feed lines and temporary storage containers to prevent spillage by collision and corrosion.
3. Clearly label all storage vessels and chemical feed lines with chemical name.

4. Check for spillage and leaks at least weekly. Leaking containers must be removed or placed in over-packs (secure containers that are larger than the leaking container).
5. Prepare a SPCC Plan under DEP guidance (see A. above). This plan shall include provisions for cleaning up small spills and containing large spills in an emergency. Keep emergency cleanup materials on hand.
6. All spills must be promptly reported to DEP, the Town (CEO and Fire Department) and the Water System.

C. CHEMICAL SPREADING OR SPRAYING

Definition: Some chemicals, including most agricultural and silvicultural chemicals, are deliberately spread or sprayed over the ground surface, or on plants. "Agricultural" applies in this case to areas of greater than 2 acres (this includes transportation or utility corridors), or hoop/greenhouses, or nursery/garden shops greater than 1,000 square feet.

Spray irrigation of wastewater and domestic use of agricultural chemicals is addressed in following subsections.

Major potential problems: Some agricultural chemicals are very soluble. If they are applied during a seasonal period of groundwater recharge (principally during the rainy spring season), much of the chemical applied will contaminate groundwater rather than being agriculturally useful.

Zoning or land use recommendation:

Zone 1: Prohibit
Zone 2: Use BMPs. Limit amount spread or sprayed as much as possible.

BMPs for spreading of agricultural chemicals:

1. All pesticides shall be applied in accordance with label directions and the regulations of the Maine Board of Pesticides Control.
2. Herbicides and pesticides must be applied only by trained personnel, i.e. by certified applicators, who must be informed regarding the delineated area of wellhead protection.
3. All agricultural fertilizers shall be applied in accordance with label directions.
4. Fertilizer applications are to be tailored to the specific needs of the crop, as determined by soil suitability analyses. Use of slow-release fertilizers is preferred.
5. Irrigation schedules shall be coordinated with pesticide and nutrient application to minimize the possibility of leaching. Do not apply to frozen ground, or immediately before storm events.
6. Notice of intent to apply agricultural chemicals shall be given to the CEO and public water supplier prior to application.

BMPs for spreading of organic materials in agriculture:

1. Industrial or municipal biosolids or incinerator ashes are not to be spread within the WHPA.
2. A Nutrient Management Plan must be provided for all farming activities within the WHPA. Such a plan shall describe how animals will be kept within the area, (number will in any case not exceed 25 animal units (1 unit =1000 lbs of live animal weight) per 10 acres of land), or how manure will be spread (no more than 50 tons of manure per 10 acres).
3. Tailor application of manures to the specific needs of the crop, as determined by soil suitability analyses.
4. Manures shall not be applied over very shallow soils (less than 1 foot) or exposed bedrock.
5. Manure shall not be applied on frozen ground, or immediately before storm events.

D. WASTEWATER AND SOLID WASTE

Definition: Wastewater results from the flushing of waste products in a water-soluble or water-based form. It can include a wide variety of different types of wastes. Solid Waste includes solid material that is either incinerated or disposed of in landfills.

Major potential problems:

1. **Domestic and municipal wastewater.**
   Domestic and municipal wastewater is high in organic matter in the process of decomposition. It is treated most commonly by aeration in a lagoon, and/or by land disposal via a septic system leachfield (drainfield). Soils are usually excellent for removing very high concentrations of bacteria within a few hundred feet from a septic system. However, leachfields are common sources of nitrate-rich leachate in groundwater. Also, many chemicals dumped "down the drain" will leach into groundwater.

2. **Chemical wastewater disposal**
   Some chemical wastes are discharged improperly via septic system leachfields. Industrial wastewater disposal is regulated by DEP. However, domestic disposal of some chemicals may result in groundwater contamination. The most common such disposal is of chlorine products, which produce trihalomethanes in groundwater.

3. **Biosolids ("sludge")**
   Municipal wastewater treatment plants commonly produce a sludge, which is mostly organic, but may also contain concentrations of metals. The material removed when cleaning a septic tank is called "septage". The use of wastewater sludge or septage as a soil amendment is still controversial, and is being researched and regulated by DEP and others.

4. **Solid waste landfills**
   Municipal solid waste disposed of in landfills produces a leachate that is very similar to domestic and municipal wastewater in concentrations and components. It too can contain chemical components that result in groundwater contamination downgradient of landfills. Liner systems on modern landfills are not completely secure.

5. **Incinerator ash**
   Municipal incinerator ash commonly has elevated concentrations of various trace metals, which could potentially be mobilized through soils to groundwater below.

6. **Wood waste**
   Wood waste, though innocuous in the woods, can be the cause of groundwater contamination beneath log storage yards and piles of wood waste (bark, slabs, sawdust). Iron and manganese, COD and tannin/lignin are all elevated and the water has a vile odor.

7. **Floor drains**
   Floor drains can wash hazardous chemicals directly to groundwater. State and Federal law prohibits them at sites where there is a significant potential for industrial, hazardous or toxic liquids – including gasoline, oils or degreasers – to drip, be spilled or washed into the floor drains.

Zoning or land use recommendation:

Zone 1: Prohibit
Zone 2: Use BMPs for septic systems and sewer pipes.

BMPs for wastewater and solid waste:

1. Municipal wastewater facilities, chemical waste disposal sites of any kind, spreading of biosolids and incinerator ash, solid waste landfills, log storage yards and lumber yards, and facility floor drains shall be prohibited in WHPAs.
2. Septic systems and sewer pipes shall be prohibited in Zone 1 WHPAs (Zone 1 is 300 ft in many cases).
3. Sewer pipes shall preferably be relocated outside WHPAs. Alternatively, pipes may be lined internally where buried within Zone 2 WHPAs.

E. STORM WATER AND PARKING LOTS

Definition: Storm water is derived from precipitation (rain or melted snow) that drains rapidly from relatively impervious surfaces such as roofs and parking lots.

Major potential problems: Impervious surfaces or grading of the land to accelerate drainage prevents natural recharge of precipitation to groundwater. Even gravel driveways and lawns drain water quickly. Storm water from "active areas" such as frequently used parking lots may contain significant concentrations of contaminants such as petroleum products, metals and salt.

(By contrast, "inactive" impervious surfaces such as roofs can produce useful, clean recharge water.)

Zoning or land use recommendation:

Zone 1: Prohibit parking areas, except for Public Water System uses.
Zone 2: Use BMPs. Limit size of parking areas as much as possible.

BMPs for storm water:

1. Zone 1 WHPAs shall have >50% unpaved area to encourage natural recharge.
2. Zone 2 WHPAs shall have >65% unpaved area.
3. Storm water from frequently used parking lots (e.g. for commercial establishments, and workplaces) shall be diverted away from WHPAs if possible.

F. ROAD MAINTENANCE

Definition: The one aspect of road maintenance that causes significant groundwater contamination is winter de-icing with salt.

Major potential problems: Uncovered sand and salt piles can leach almost half their salt into groundwater. The use of pure salt on highways has increased the incidence of nearby domestic wells becoming contaminated. Gravel roads used to be oiled.

Zoning or land use recommendation:

Zone 1: Minimize use of salt.
Zone 2: Use BMPs. Limit size of pile as much as possible.

BMPs for road maintenance:

Cover all sand and salt piles
Do not oil roads
Use water to keep dust down on gravel roads
Minimize use of salt in all cases.

G. RESIDENTIAL ACTIVITIES AND HOME OCCUPATIONS

Definition: Residential activities include: production of septic wastes, use of gasoline or fuel oil, automotive or similar shop work, lawn or garden care with fertilizers and pesticides, and use and disposal of chemicals from home occupations such as photographic studios, beauty salons, car washing activities, etc.

Major potential problems: Most homes contain stores of small quantities of several hazardous chemicals (gasoline, fuel oil, bleach, paint thinners, pesticides, drain cleaners, etc.). Many

homeowners are unaware that disposal of small quantities of these chemicals through septic systems or on the ground may cause significant groundwater contamination.

Zoning or land use recommendation:

Zone 1: Prohibit residential uses if possible.
Zone 2: Use BMPs. Limit number of residences as much as possible.

BMPs for residential activities:

1. Residential uses should be prohibited in Zone 1 WHPAs if possible. If allowed they should be located on lots of at least 5 acres, with a requirement that septic wastes are to be disposed of at least 300 feet from the well and with at least 10 feet of soil cover, and a replacement leachfield be designated with similar stipulations.
2. Residential uses may be allowed in Zone 2 WHPAs, with net density of at least 2 acres/unit, with a requirement that a replacement leachfield be designated on each lot.
3. Developers of residential subdivisions within WHPAs shall complete a nitrate loading study. The concentration of nitrate at the well shall be calculated, using the following conservative estimates: concentrations of nitrate leaching from the septic system: 40 ppm; volume of leachate per day per housing unit: 360 gallons; natural recharge rates for precipitation through soils: 0.5 gallons per minute per acre. Such mass balance calculations shall be performed using the same estimates for all existing septic systems and for proposed future developments. In order to be allowed, the applicant must find that nitrate concentrations will not exceed 25% of drinking water standard at the well.
4. Residents of properties located within Zone 2 WHPAs should be informed of the potential for groundwater contamination from domestic use of various chemicals.
5. Home occupations proposed for WHPAs shall come under Planning Board review for consideration of how they may impact groundwater quality. No disposal of chemicals from home occupations shall be allowed within WHPAs.
6. Vehicles within Zone 1 WHPAs must be parked on impermeable surfaces.
7. Home heating oil tanks shall be prohibited in Zone 1 WHPAs, and replaced with alternative fuel or heating sources.

Any spills from residential activities should be reported to the Public Water Supply and CEO.

H. GRAVE SITES

Definition: Gravesites include not only human cemeteries, but also mass graves for animals (with >1000 lbs of carcass in one burial site).

Major potential problems: Single burials are not a problem (animal wastes accumulated over one year of life are greater in volume and weight than a dead animal carcass). However, mass graves can overload the soil's capacity to decay organic material and can cause significant deterioration of groundwater quality. Fortunately, composting of carcasses produces no leachate or groundwater contamination.

Zoning or land use recommendation:

Zone 1: Prohibit
Zone 2: Use BMPs.

BMPs for cemeteries:

1. Cemeteries should not be permitted in Zone 1, WHPAs.
2. Carcasses should be composted rather than buried.

I. FIRE PROTECTION

Definition: Firefighting includes prevention as well as activities associated with emergency dowsing of fires.

Major potential problems: Water used to control fires at chemical storage sites can cause widespread groundwater contamination because the water becomes contaminated before leaving the site.

BMPs for firefighting within WHPAs:

1. Prepare "Pre-Plan" for fire prevention and fire suppression for all facilities within WHPAs. These plans should be tailored to the materials stored on site, and designed to limit groundwater contamination in the event of fire.

J. MINING

Definition: Mining involves the removal of mineral materials from the earth. It can include excavation of sand and gravel, removal of rock, or extraction of metallic ores.

Major potential problems: Mining for metallic ores presents the greatest problem in regards to water quality, with generation of leachate that is generally acid and with high concentrations of metals. Mining for rock or sand and gravel may, under some circumstances, cause unintended changes in the flow of groundwater. Any mining produces pits, which can be used for illegal dumping. Vehicles used for mining may be the cause of spills. Rock crushers use water that may wash pollutants into the groundwater.

Zoning or land use recommendation:

Zone 1: Prohibit
Zone 2: Use BMPs. Limit size as much as possible.

BMPs for mining:

1. Mining for metallic ores shall be prohibited from WHPAs.
2. Mining for rock or gravel shall be prohibited in Zone 1.
3. Storage of fuels in gravel pits or rock mining areas shall be prohibited in WHPAs.

4. Rock crushers shall be prohibited in WHPAs.
5. Disused gravel pits within WHPAs shall be reclaimed according to plans submitted to the Municipality.
6. Gravel mining activities in WHPAs must have emergency spill response plans and equipment on hand such that a spill totaling the full fuel tanks of the largest vehicle used in the pit can be removed outside the WHPA within one day.

K. FILL

Definition: Fill is contaminated if it has a non-natural odor, or is stained, or comes from a known source of contamination, such as the site of an underground tank removal project.

Major potential problems: Contaminated fill can become the source for groundwater contamination for long periods, as the contamination is leached out into the subsurface.

BMPs for fill:

1. Use only inert material (loam, sand, gravel, clay, rocks, bricks or concrete).
2. Use only clean fill (no non-natural odors, no staining, and not originating at a known spill site).
3. Implement erosion and sedimentation control measures.

L. WELLS

Definition: Wells are structures (usually vertical shafts) used to access groundwater for extraction or monitoring purposes.

Major potential problems: Wells provide a possible conduit for contaminants originating in surface water or upper aquifers to migrate to groundwater below. Wells placed within the same Zone of Groundwater Contribution will interfere with each other, causing a reduction in the Safe Yield of both.

BMPs for wells:

1. Wellheads shall be designed such that surface water does not enter groundwater through the borehole around the well casings.

2. Wells that are no longer in service for extraction or monitoring shall be abandoned in a manner appropriate to prevent the entry of contaminants and mixing of separate subsurface water-bearing zones. This may involve the use of bentonite and/or cement grout where a water-tight seal is deemed necessary.
3. High yielding wells (for uses other than domestic purposes) will only be allowed in the WHPA if a safe yield analysis, conducted by a Maine Certified Geologist, can demonstrate that there is sufficient water for both the new well and the public water source.

Table 1: Potential Contamination Sources and Groundwater Protection for Maine Drinking Water Program: Source Water and Wellhead Protection Program

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Maine Rural Water Association with
Emery & Garrett Groundwater, Inc.